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Date: 3/3/81

Project Title: Demonstration of Fresnal Spiral Concentrator Solar Cooker.

Project No: A-2872

Project Director: Mr. J. D. Walton

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Sponsor: Midwest Research Institute, Solar Energy Research Institute Division; Golden, CO 80401

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SPONSORED PROJECT TERMINATION

Date: 6/1/81

Project Title: Demonstration of Fresnal Spiral Concentrator Solar Cooker

Project No: A-2872

Project Director: Mr. J. D. Walton

Sponsor: Midwest Research Institute, Solar Energy Research Institute Division; Golden, CO 80401

Effective Termination Date: 5/15/81

Clearance of Accounting Charges: 5/15/81

Grant/Contract Closeout Actions Remaining:

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FINAL SUMMARY REPORT

DEMONSTRATION OF FRESNEL SPIRAL CONCENTRATOR SOLAR COOKER IN BAMAKO, MALI - AFRICA

By

J. D. Walton

For

Solar Energy Research Institute
1617 Cole Boulevard
Golden, Colorado 80401

May 1981

Project A-2872

Georgia Institute of Technology
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IN BAMAKO, MALI - AFRICA

FINAL SUMMARY REPORT

PROJECT A-2872

J. D. Walton

May 1981

I. OBJECTIVE

The principal objective of this project was to construct, assemble, and demonstrate a new type of solar cooker in Mali. This cooker utilized the recently developed Georgia Tech spiral concentrator; a concentrator that can be fabricated in the village situation from inexpensive, readily available materials by unskilled labor using simple hand tools. A further objective was to construct a VITA concentric ring Fresnel concentrator to compare with the Georgia Tech spiral concentrator; both cookers using the same reflective surface. In addition to the VITA cooker, sufficient material was shipped to Mali to fabricate an additional Georgia Tech concentrator using an alternative reflective film so that a comparison of two different films could be made. The overall aim of this program was to transfer the know-how for fabricating and assembling the spiral concentrator cooker units to Malian engineers at the Solar Energy Laboratory (SEL). In support of the objectives a series of lectures on solar powered pumps, high temperature solar energy and solar thermal test facilities were provided to the SEL staff.

II. BACKGROUND

During recent years there has been growing world concern over the ecological problems and human suffering that are resulting from the increasing cutting of wood in developing countries. Wood fuel for cooking is a significant part of the energy budget in the Third World, generally representing about 50 percent of the fuel used 1/. Not only is widespread desertification resulting from the increasing demand for fuel wood, but the accompanying loss of water shed and water table in many countries threatens future food crops and human life due to diminishing water resources. Clearly, developing solar cookers that could find widespread acceptable and thus significantly reduce fuel wood consumption would solve one of the most serious ecological and energy problems facing many of the developing countries of the world.

A. The Non-Acceptance of Solar Cookers

Although solar cookers have been the subject of countless research, development and evaluation activities for more than 100 years, they remain probably the least used of current solar technologies.

Typically, the reasons given for the lack of acceptance of solar cookers are: (1) too expensive, (2) too complicated, (3) not traditional, (4) danger of getting burned or eye damage, (5) cooking must be done in direct sun, (6) cooking can only be done during the middle of the day, (7) they must be imported, (8) cannot cook traditional dishes, etc. 2/. Certainly many of these reasons may apply in some area of the world, and one or more in many areas of the world. However, it is suggested that their lack of use runs deeper than these reasons alone. In fact, during the survey of the state of the art of solar cookers 3/ it was found that the reasons given above for the lack of acceptance were based more on the opinion of the solar technologist and hearsay than on the results of extensive efforts to introduce solar cookers into the actual village situation. In fact, only two programs involving long term efforts to diffuse this technology into rural villages were found; one in Mexico 4/ and one in Upper Volta 5/. The results of these programs suggest that solar cookers will be accepted only through a serious and continuous program of introduction, education and training, and that women must play a major role in all phases of the program for it to be successful.

Although the ultimate success of any solar cooker introduction program will depend on method of introduction, education and training, the solar cooker itself must meet certain technical and economic requirements in order to facilitate acceptance. It must, of course, cook the traditional dishes during approximately the usual time period, it must be simple to operate and be made from inexpensive and preferably locally available materials with the potential of in village fabrication. A new solar cooker which is capable of meeting all of these criteria is the spiral Fresnel concentrator developed at Georgia Tech.

B. The Georgia Tech Spiral Concentrator

The Georgia Tech Spiral concentrator was invented by Richard Steenblik while a student at Georgia Tech. His objective was to develop a simple inexpensive concentrator for a solar cooker that could be constructed from readily available materials and be easily fabricated in a village situation by unskilled labor. Initially, his idea was to design a Fresnal reflector using concentric rings formed from a sheet of suitable flat material and coated with a reflective film. When he learned that this concept had previously been developed by VITA 6/, he then conceived the idea of the spiral Fresnel concentrator. Very simply his idea was to use a flat sheet of suitable material cut into the form of a spiral. By attaching the spiral to a planar surface and slightly coiling it, like a spring, each element of the spiral surface would assume a natural twist that would cause each point on the surface to reflect light, directed along the axis of the spiral, to be reflected through a common focal point.

C. Constructing the Georgia Tech Spiral Concentrator 7/

The first step in developing a spiral concentrator is to select the desired concentration ratio and focal length for the particular application. This information is then used in a computer program to generate a spiral pattern and to locate a set of mounting points. These mounting points are located so that when they are aligned in a straight line and attached to a planar surface (during construction of the concentrator), each spiral segment assumes the proper angle (twist) to make the reflector a point focusing concentrator.

For the solar cooker application a concentration ratio of 75 was selected with a focal length equal to the radius. The concentration ratio determined the relative width of the spiral segment (the wider the segment the lower the concentration) and the focal length determined the degree of twist (the greater the twist the shorter the focal length).

The completed computer pattern is then photographically enlarged to the size necessary to provide the desired thermal power level. Typically the solar cooker pattern was enlarged to a diameter of 1220 mm (four feet) since the concentrator was to be made from a sheet of pressed wood board 1220 mm x 1220 mm. (This diameter provides typically 500-600 watts at the focal point.)

For a typical solar cooker application a 3 mm (1/8-inch) thick 1220 x 1220 mm square piece of Masonite is used as the construction material for the spiral. One surface of this board is covered with kitchen type aluminum foil using a household type, water soluble glue. Using the same glue, the spiral pattern is then bonded to the aluminum surface. After the pattern dries, two 2 mm diameter holes are drilled at each of the mounting points. Using a keyhole or saber saw, the spiral is then cut from the board by cutting along the lines of the pattern. The pattern is then removed from the reflective surface after soaking it with water. Two pieces of 20 mm x 60 mm x 1200 mm lumber are used to make a right-angle cross frame onto which the spiral is attached at the mounting points using 1 mm wire. Typically, in the United States, the retail cost of the materials used to make this concentrator is only about $5.

Because of the simplicity of the Georgia Tech spiral concentrator, its ease of construction and use of inexpensive, readily available materials, SERI initiated the program to carry out the construction and demonstration of this system as a solar cooker in Mali, West Africa. The following section summarizes the results of that program.

III. SUMMARY OF PROGRAM ACTIVITIES

A. Introduction

During March 24 - April 4, 1981 the work specified in the program to demonstrate the Fresnel concentrator solar cooker was carried out in Bamako, Mali. This work is summarized in Sections B. Solar Cooker Construction and Demonstration and C. Lectures. In addition to the objectives set forth in this program there was an opportunity to participate in a wood stove development activity at the Solar Energy Laboratory using local clays from the Bamako area. The results of this participation are summarized in Section D. Mud Stove Development.

B. Solar Cooker Construction and Demonstration

1. Materials Selection. In order to expedite the construction and demonstration of the spiral solar cooker in Mali, and to facilitate the transfer of the spiral concentrator technology to engineers in the Solar Energy Laboratory in Mali, all of the materials necessary to construct six concentrators were shipped by air freight to Bamako. These included six sheets of 3 mm x 1220 mm x 1220 mm pressed board (untempered Masonite), aluminum foil, two 1220 mm x 1220 mm of YS-91A (3M reflective film), household glue, six Georgia Tech spiral patterns, 19 pieces of 20 mm x 50 mm x 1200 mm lumber for cross members, one VITA pattern, one set precut cross members for one VITA concentrator, plastic coated wire, two keyhole saws and four saw blades, one electric saber saw and twelve blades and one yankee drill with assorted drill bits.

a. The Spiral Concentrator. After arriving in Bamako visits were made of the various shops and markets to determine the availability of local materials for constructing the spiral concentrator. At one time 3 mm thick pressed wood board had been available in Bamako and may yet be available in West Africa. The alternative material available in Bamako was 4 mm (5/32 in.) thick plywood 1220 mm x 2440 mm (4- x 8-ft), which cost 4,500 FM (about $9). Also, galvanized sheet steel about 0.5 mm (0.02 in.) thick and 1000 mm x 2000 mm was located at a price of 3,500 FM (about $7).

Although it was not priced, kitchen type aluminum foil also was available locally as were all of the other materials necessary to construct the Georgia Tech spiral concentrator.

b. The Solar Cooker Support Frame. In order to construct a working solar cooker it is necessary to provide some type of frame or structure to support the concentrating collector and the foods to be cooked. For the demonstration cookers using the Georgia Tech Spiral concentrator and the VITA Fresnel concentrator it was decided that a design developed in Upper Volta would be used. Typically, the concentrator used in point focusing type solar cookers is supported on a "U" frame which pivots on a vertical shaft at the bottom of the "U" frame to allow the reflector to follow the east-west motion of the sun. The food is typically supported on a platform suspended across the top of the "U" frame at the focal point of the concentrator. In the case of the Upper Volta cooker, the support system for the concentrator and the food was designed and developed in-country by a technologist in collaboration with the local people. This design incorporated several significant and novel features which greatly facilitated the use of such cookers. These features are: (1) the support frame for the paraboloid dish: this frame consisted of two vertical members resting directly on the ground and connected by a cross member and forming a "T" section on the ground for added stability. There was no provision for rotation east-west to follow the sun. (The pivoting of the usual solar cooker on a simple shaft provided for a very unstable support system), (2) the vertical support members: these extended beyond the focal length of the concentrator to a height that permitted the food to be hung from the cross member connecting the top of the two vertical support members. By suspending the food, further safety was provided for the food so that, if the cooker was accidently shaken, the food was mechanically isolated so that it merely swung on the hanging members, and

(3) <u>support of the food</u>: by hanging the food and orienting the cooker so that it faced south (adjusting only for the sun's altitude) the food itself was moved on the top cross member to follow the reflected concentrated image as it moved west-east. Thus the principal of operation of this new cooker was one that provided for the food to be moved to follow the moving reflection of the sun instead of having to turn the entire concentrator and frame to follow the motion of the sun. This unique design provided an excellent example of what can be accomplished through technology exchange between industrialized and developing countries working in the village situation and emphasized the importance of local involvement which is necessary in any attempt to introduce technology into village or rural life.

The Upper Volta cooker support frame was made from 25 x 25 mm angle iron. However, for the Mali demonstration using the Georgia Tech spiral concentrator the decision was made to use wood for the frame, since the spiral concentrator is much lighter than the paraboloid dish used in the Upper Volta cooker. For this frame, 30 mm x 60 mm pieces of wood were ripped from locally available 30 mm x 200 mm lumber.

<u>2. Fabrication</u>. Mr. Sidibé, the engineer in charge of high temperature solar thermal applications, was designated as the Solar Energy Laboratory Engineer who would be trained in the fabrication, demonstration and use of the spiral solar cooker. With the exception of the initial effort in each step in constructing the first concentrator, Mr. Sidibé carried out all aspects of the fabrication process during this program.

The following sections describe the procedure used in constructing both the Georgia Tech spiral concentrator and the VITA Fresnal concentrator.

a. Application of Reflective Film. A 50/50 mixture of Elmer's glue and water was applied to one third of the surface of the masonite sheet using a paintbrush. The glue mixture was applied to a width slighly wider than the aluminum foil. While the glue was still wet, the roll of aluminum foil was unrolled onto the wet surface with the polished side away from the Masonite. As the foil was unrolled a soft cloth was used to smooth the foil onto the Masonite and remove any air trapped under the film. This process was repeated two more times until the surface of the Masonite was coated with the foil. Time 30 minutes.

In addition to the kitchen type aluminum foil used on the VITA concentrator and one of the Georgia Tech spiral concentrators, an aluminimized plastic film was applied to a second Georgia Tech spiral concentrator. The film used was 3M type YS-91A reflective film, with a water activated adhesive film. With this film it was necessary only to wet the back side of the film and apply it to the Masonite surface as a single sheet since the width was 1320 mm (52 inches). Time: 10 minutes.

b. Application of Cooker Pattern. After the foil had been smoothed on surface of the Masonite the 50/50 glue/water mix was painted onto the foil surface. The cooker pattern was then positioned onto the still wet foil surface and smoothed into position. Since the pattern was printed on blue-line paper, the pattern became somewhat wrinkled as it absorbed the glue. However, due to the nature of the pattern, this wrinkling presented no problem and it was not necessary to try and obtain a smooth surface with the pattern. Time: 10 minutes.

c. Cutting the Pattern. The pattern was allowed to dry for about one hour before the next step. For the Georgia Tech spiral concentrator it was necessary to drill mounting holes before cutting the spiral pattern. Some 24 to 26 pairs of 2 mm holes were drilled in the pattern used for this project. Time: 20 minutes.

A keyhole saw was used to cut the VITA Fresnel and the Georgia Tech spiral concentrators from the aluminum foil coated Masonite sheet. Although Mr. Sidibé had never used a keyhole saw, only a short period of time was required for him to become familiar with its use. After this he was able to proceed with the sawing operation with normal dexterity. Time: 45 minutes.

d. Removing Patterns. The pattern was removed from the cut Masonite by soaking it with water. This was done by thoroughly wetting the surface using the paintbrush previously used for applying the glue. After soaking, the pattern was easily peeled from the aluminum surface. Time: 15 minutes.

e. Cross Frame for Supporting Concentrator. A special cross frame was required for the VITA concentrator. This was made from 20 mm x 100 mm lumber and precut at Georgia Tech and carried with baggage to Bamako. This frame had a series of notches cut at precise angles to support each of the concentric rings of the Fresnel reflector segments that make up the VITA concentrator. The pattern for this cross member was supplied by VITA as part of their instruction booklet.

The cross member for the Georgia Tech spiral concentrator consisted simply of two 20 mm x 40 mm pieces of wood 1220 mm long and notched in the center so that a right-angle cross frame resulted with the 20 mm surfaces of both members forming a common plane. Time: 20 minutes.

f. Attachment of Concentrators to Cross Frame. The Georgia Tech spiral concentrator was attached to the 2 cm wide surface of the cross members by using plastic coated wire inserted through the holes previously drilled at the mounting points. The mounting process was started by first attaching the outermost segments of the spiral to the outer edge of the cross frame and proceeding toward the center, coiling the spiral to bring the mounting points into a straight line. Time: 30 minutes.

The VITA concentric rings were attached to the specially cut cross member by nailing each ring to the appropriate cut section.

g. Solar Cooker Support Frame. The design for the solar cooker support frame was based on the one developed in Upper Volta and described in prior Section III.B.1.b. The construction material consisted of three pieces of wood 30 mm x 60 mm x 6 meters long which was obtained from a lumber dealer in Bamako.

Since the Upper Volta support frame was made from 25 mm x 25 mm angle iron some modification in the design of the wooden prototype frame was necessary in order to obtain sufficient rigidity. This was provided in part by a 1300 mm long 20 mm diameter pipe that was used as the horizontal member that connected the top of the vertical support members and supported the food or food container to be heated by the solar concentrator. A piece of 30 mm x 60 mm wood about 1350 mm long was used to connect the bottom of the vertical support members. Another piece of 30 mm x 60 mm lumber, 1000 mm long was attached at its center and at right angles to this bottom horizontal connector at the bottom of one of the vertical support members. These pieces of lumber formed a "T" section on the ground to provide lateral and longitudinal support for the vertical members. The distance between the vertical support members was such that the concentrator had ample space to hang and swing between them.

The hanging support for the food or cooking pot was made from 6 mm iron rod formed into a 200 mm diameter ring with two vertical support rods 300 mm long welded on opposite sides and at right angles to the plane of the ring. The free end of these rods was bent to form a hook so that it could hang from the 20 mm horizontal pipe. The food support was designed and fabricated by the Solar Energy Laboratory technician in charge of welding and metal working. Time for making this food support was not determined. Time for Solar Cooker Support Frame: 2 hours.

h. Concentrator Support Arms. Two concentrator support arms were used to connect the concentrator to the cooker support frame. These arms were made from 20 mm x 50 mm x 800 mm pieces of wood with a 20 mm diameter hole centered about 30 mm from one end and a 20 mm x 50 mm rectangular hole at the other end. The edge of this hole was about 20 mm from the end of the arm. The distance from center of the 20 mm diameter hole to the closest edge of the rectangular hole was 700 mm. The distance corresponded to the focal length of the Georgia Tech concentrator. The rectangular holes were fitted over opposite ends of one of the concentrator cross frame members so that they were parallel to the axis of the concentrator. The other ends were placed over two 16 mm dowels attached to the two vertical members of the support frame. These dowels were located at the height of the cooker support ring hanging from the 20 mm pipe at the top of the vertical support members. With this arrangement the concentrator could be rotated about it's focal point which was coincident with the food support ring. Time: 60 minutes.

3. Assembly. Assembly of the solar cooker involved only the connection of the concentrator to the cooker support frame using the two concentrator support arms described in the previous section.

4. Operation and Testing.

a. Operation of the Cooker. Typically the assembled solar cooker would be set up so that the swinging motion of the concentrator on the support arms would be in a north-south direction. However, in Bamako, at the end of March and first of April the sun is directly overhead at noon. Thus the sun's path is more or less a straight line from east to west passing overhead. Therefore, there was no clear advantage in positioning the cooker so that the swing of the concentrator was north-south rather than east-west. Since the limited testing carried out as part of this program was from about 10 a.m. until about 1 p.m. the orientation selected was east-west.

When the cooker was first set up in the morning it was oriented in an east-west direction facing the sun. The concentrator was hanging in a horizontal position and the operator stood on west side of the concentrator facing the sun. The food support ring, hanging from the 20 mm pipe, was moved along the pipe (north-south) until it was over the center of the concentrator. The edge of the concentrator next to the operator was pulled back and upward toward the operator until the focal point was centered on the food support ring. One end of a small piece of wood, about 500-600 mm long was placed between bottom of edge of the concentrator, nearest the operator, and the ground. This stick was used to hold the concentrator in the correct vertical alignment to keep the focal spot on the food support ring. Since the operator was behind the cooker he was out of the glare of the concentrator and could easily observe the movement of focal spot as it was brought onto the food support ring.

b. Test Results. Two solar cooker support frames and food support rings were made so that simultaneous, comparative tests could be carried out. Two such tests were conducted as part of this program. One was to compare the performance of the Georgia Tech spiral concentrator and the VITA Fresnel concentrator, both using aluminum foil as the reflective surface. The other was to compare two Georgia Tech concentrators, one using aluminum foil and the other using the aluminized plastic film YS-91A.

These comparative tests used locally purchased, cast-aluminum cooking pots (about three-liter capacity) to contain one liter of water which was heated by the concentrated solar energy. The bottom surfaces of these pots were blackened by placing them over a smoking fire for about 20 minutes. The tests consisted of measuring the temperature of the water, with a thermometer as a function of time exposed to the solar radiation. Measurements were made approximately every 15 minutes. Total and indirect solar radiation measurements also were made at the same time that water temperature measurements were made. The solar radiation measurements were made using a hand held solar cell type instrument.

Figure 1 presents the comparative data obtained for the Georgia Tech and VITA concentrators. The first test was run between 10 and 11 a.m. on April 2. After about 30 minutes it was decided that the pots containing the water would be covered to reduce evaporation. The second test was run between noon and 1:30 p.m. For these second tests the aluminum pots were exchanged so that any difference in absorptivity would be normalized by the two test runs.

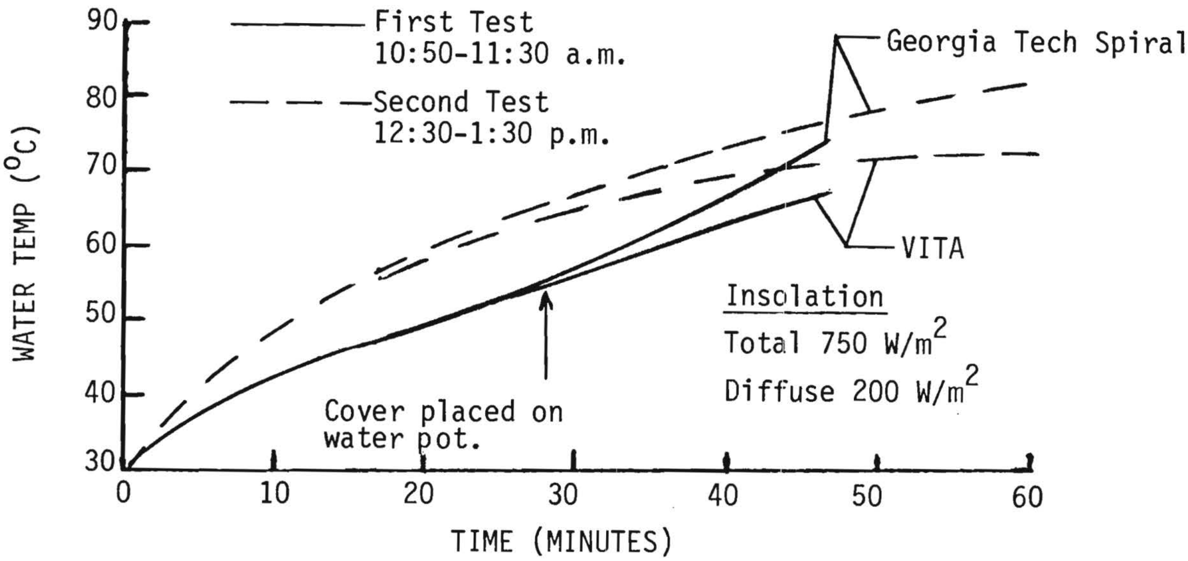

Figure 1. Water Temperature vs Time Heated by VITA Fresnel and Georgia Tech Spiral Concentrator.

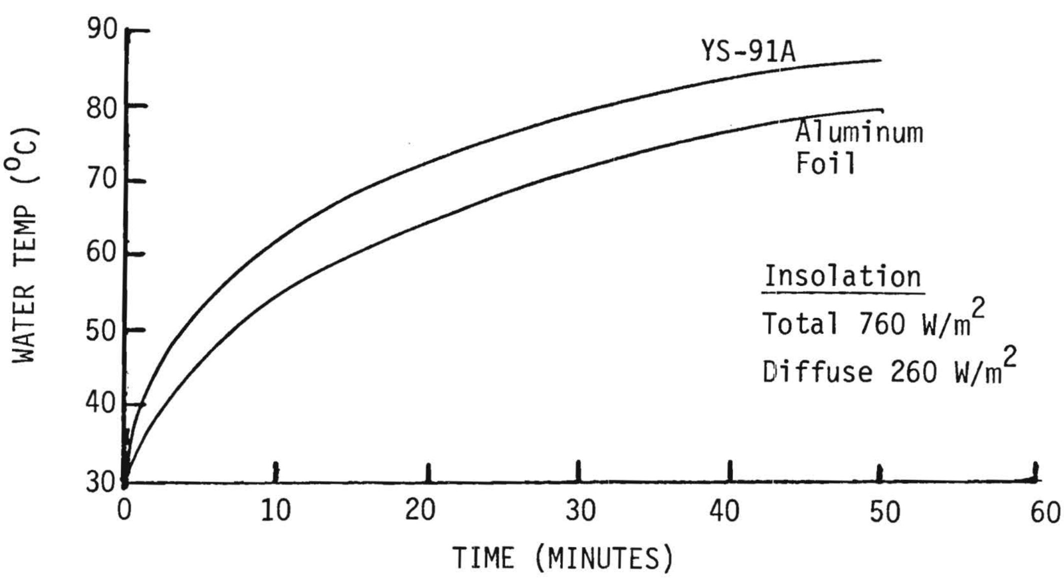

Figure 2. Water Temperature vs Time Heated by Georgia Tech Spiral Concentrator using Aluminum Foil and Aluminized Plastic (YS-91A) Reflector Films.

Figure 2 presents the data obtained for the two Georgia Tech spiral concentrators, one with aluminum foil and one with the YS-91A reflective film. For these tests the water pots were covered throughout the tests. These tests were run between 10 and 11 a.m. on April 3.

c. Discussion of Results. The emphasis of this program was to transfer the technology for fabricating and operating the Georgia Tech spiral cooker to the technical staff at the Solar Energy Laboratory at Bamako. Since this operation occupied the majority of the time in Bamako, only a very preliminary type of test program could be carried out. Therefore, the results presented here should be considered as very rough measurements of the performance of these cookers. However, some general conclusions can be made.

(1) The Georgia Tech spiral concentrator and the VITA Fresnel concentrator provided equivalent performance data. Due to the apparent higher concentration ratio the Georgia Tech concentrator may provide slightly higher efficiency at the higher water temperature.

(2) The YS-91A aluminized film provided a definitely higher heating rate than the aluminum film. This is as would be expected since both the specularity (greater than 90 percent) and the specular reflectivity (above 85 percent) are both significantly higher than aluminum foil.

C. Lectures

On March 26 and 27 two one hour lectures were given to the technical staff of the Solar Energy Laboratory (SEL). These were presented during the time normally used for English lessons given by a Peace Corps Volunteer. The lecture on the 26th was on the subject of High Temperature Solar Energy and Solar Thermal Test Facilities. The subject on the 27th was Small Scale Solar Power, Solar Water Pumps and Solar Cookers. A copy of the collection of papers, articles and notes used for these lectures was left for the SEL library.

D. Mud Stove Development

During the course of the project in Mali the opportunity developed to contribute to an effort in the Solar Energy Laboratory to develop mud stove technology. This activity was in three areas: 1. use of local clays, 2. experimental clay/sand/grog mixes, and 3. opportunities for local pottery technology.

1. Use of Local Clays. Mr. Andre, a Peace Corp Volunteer in charge of mud stove development located a clay deposit near Bamako through a local potter. Samples of this clay were taken from this deposit and used in the preparation of experimental mud stove compositions. This clay was dark blue-gray color and was very plastic, being similar to typical ball clays in the United States. The high plasticity was to be desired from the standpoint of workability and dry strength, but presents potential problems in drying which may lead to cracking because of its high drying shrinkage. All things considered the local clay near Bamako appeared to be a very good one for making mud stoves. Mr. Andre had made a two-pot stove for the wife of the gardener at the SEL and it had performed so well that it had been her sole means of cooking since its construction earlier this year.

should not be prohibitively expensive if made by local potters. The desirability and asthetic appeal of such an item together with more efficient use of wood for cooking could well promote their use in the urban situation. To explore this possibility, visits were made to a local potter and to a large whiteware plant currently under construction by the Chinese. The skill of the local potter appeared to be adequate for the fabrication of the ceramic stove top. However, since the method of firing by this potter was very primative there was some question as to whether or not the stove top could be fired without cracking or warping.

The whiteware plant was of essentially modern design and would certainly have the capability for making and firing the stove top. However, the cost of the top made at such a plant might be prohibitively expensive. A better choice might be a local potter who uses a kiln that provides a higher grade product than the potter that was visited during this trip.

IV. CONCLUSIONS

1. The objectives of the solar cooker project were met. The technical staff of the Solar Energy Laboratory demonstrated competence in constructing and operating the Georgia Tech spiral cooker. This competence included the use of simple hand tools and the ability to work under conditions similar to the village situation. Locally available materials were identified from which the cookers could be constructed and the staff has the know-how to instruct others in the construction of the cooker.

2. The Georgia Tech spiral cooker and the VITA Fresnel cooker were evaluated simultaneously and found to give equivalent performance. Both cookers used aluminum foil as the reflective surface. An aluminized plastic film, YS-91A and aluminum foil were compared on two Georgia Tech spiral cookers. The plastic film gave the better performance in accordance with its better reflectance.

3. A source of local clay was examined with respect to mud stove fabrication. The clay was found to have good working characteristics and could be used by local potters to make ceramic stove tops with improved durability and asthetic appeal. It was considered that an urban market might be developed for such a project.

V. RECOMMENDATIONS

1. A program should be undertaken to identify and evaluate alternative materials to replace Masonite in the construction of the spiral concentrator. Plywood and galvanized sheet steel should be considered, although both probably will be too expensive. Novel materials such as resin or varnish impregnated cardboard or fabric materials also should be evaluated. Materials that can be used to make concentrators greater than 1200 mm in diameter should be considered in order to obtain more thermal power.

2. The present solar cooker support frame was made from wood. Since termites are a problem in most areas of Mali the wood should be treated. Methods of treating should be examined that will not be objectionable to the user. Angle iron or other locally available metal should be used to make prototype support frames. These should be compared with those made from wood from the standpoint of durability, cost, ease of fabrication and users acceptance.

3. A project should be undertaken to initiate some type of instutional activity, probably through an existing women's program to begin interacting with the potential user of the solar cooker. Methods for introduction, instruction, preparation of foods, etc. should be developed as part of such a program. Consideration should be given to an introduction program for urban areas as well as rural villages.

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